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THESIS

A REGRESSION MODEL OF THE EFFECTS OF PERSONNEL CHARACTERISTICS ON AVIATION READINESS AND PRODUCTIVITY

by

Thomas Robert Maxfield

December 1985

Thesis Co-Advisors: Loren M. Solnick
David R. Whipple

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A Regression Model of the Effects of Personnel Characteristics on Aviation Readiness and Productivity

by

Thomas Robert Maxfield
Major, United States Marine Corps
B.S., California State College at Long Beach, 1979

Submitted in partial fullfillment of the
requirements for the degree of

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ABSTRACT

A multiple regression model demonstrating the impact of personnel characteristics on unit effectiveness was developed. Personnel and aircraft data was compiled on nine U.S. Marine Corps F-4 fighter aircraft squadrons for the analysis. Conclusions identified several personnel characteristics that have an impact on a squadron's mission capable rate. It was recommended that further analysis be done acquiring and analyzing several other personnel characteristics and their impact on this model.

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I. INTRODUCTION

A. PURPOSE

The purpose of this thesis is to examine the relationship between the performance of an aviation squadron and the characteristics of its personnel. The emphasis is on identifying the characteristics which have the greatest and most significant impact on the effectiveness of a U.S. Marine Corps fighter squadron. If a model can be developed that accounts for these variables, then forecasting probable productivity/readiness (in terms of the dependent variable) can be accomplished, and better predictions can be made regarding the impact of manpower policy decisions on squadron performance.

In a commercial enterprise, profit and loss are used to measure the success and failure of the firm. It is also used to determine the feasibility and advisability of personnel decisions. The hiring of additional personnel often must be justified by an increase in market share or as a result of expansion requirements. Precise formulas have been developed that show how much additional revenue must be generated to warrant the additional manpower costs under consideration.

In the military there is no profit and loss index or other measure that can be utilized to justify and procure additional resources. There is not a simple common measurement that can be used as a yardstick of the productivity/readiness of a military unit. How then, particularly in a time of relative peace, can the military justify its resources, particularly in the area of manpower? As manpower costs continue to soar, so will congressional requirements for tangible evidences and concrete support of military requests and expenditures.

The military has long been able to identify how much it costs to acquire an E6 with specific military training and qualifications. What it has not been able to show is the contribution that this individual makes to the unit's readiness/productivity. Until models can be developed that will explicitly dissect and demonstrate this contribution, all of the military billet cost models will remain incomplete and distorted.

B. OBJECTIVE

The objective of this thesis is to explore personnel characteristics and what impact they have on unit readiness/productivity. This study is a macro approach to the problem. It is intended to explore the feasibility of such models and serve as a general guide in the further development of models that are used to explore billet cost models.

C. SCOPE, LIMITATIONS AND ASSUMPTIONS

This study focused on U.S. Marine Corps F-4 fighter squadrons during the period 1 April 1980 to 31 March 1985. Since the emphasis of this thesis is on personnel characteristics, variables such as squadron leadership, location, facilities and weather were dismissed in order to maintain that central focus. Because the readiness measures utilized focused on the material condition of the aircraft, the research data focused on the squadron maintenance department, ignoring the maintenance augmentees and all other squadron personnel not directly associated with the maintenance of the squadron aircraft.

This thesis was not severely limited or constrained by available data, particularly on the squadron aircraft. Data is readily available that gives a complete breakdown of every work center, accounting for every minute of every day for every person and every aircraft in the squadron. Detailed records of the amount of maintenance time spent on each and every system and subsystem are kept and analyzed. Future studies will find these data invaluable in developing future models. The personnel data were limited by what was recorded in the Master Files at Headquarters, U.S. Marine Corps. This limitation precluded expanding the model by including several other independent variables. These are discussed in Chapter VII.

The starting date for the data was selected based on the incorporation of several new methods of data reporting that became effective in 1979. A new reporting system was developed and implemented allowing for more accurate and precise records to be kept.Since the data did not become relatively error-free until early 1980, the starting point for this study was April, 1980.

The number of squadrons for this analysis was reduced to the nine F-4 squadrons that maintained and utilized the F-4J/S aircraft throughout the entire interval being studied. It was assumed for this thesis that each of the nine squadrons analyzed had the same responsibilities and training considerations. It was also assumed that each unit was staffed at a fair share of the available manpower pool.

D. SUMMARY OF FINDINGS

A regression model was developed that supported the importance of several personnel characteristics to the effectiveness of a Marine aviation unit. The number of personnel, divided into E1 to E5 and E6 to E9 proved to be statistically significant and have a positive impact on mission capable rates (MC). Non-maintenance schools had a positive impact on MC while maintenance schools had a negative impact on it.

The computed elasticities of the means were revealing as well. A ten percent increase in E1 to E5 personnel yielded a 3.2 percent increase in MC compared to a 1.7 percent increase for the same ten percent increase in E6 to E9 personnel. Since the average number of personnel that are E5 or below is more than four times greater than the average number of E6 to E9 personnel, the effect of one additional E6 to E9 on MC is more than twice the effect of one additional E1 to E5.

II. BACKGROUND

In order to properly understand the logic and reasoning of the analysis and the conclusions drawn from the model, an elementary understanding of U.S. Marine fighter aviation is required. While very general in nature, this information is vital to the proper understanding of the regression model that was developed.

A Marine F-4 squadron is comprised of approximately two hundred thirty-five enlisted Marines, thirty-five officers and twelve fighter aircraft. There are currently twelve active duty fighter squadrons in the U.S. Marine Corps. Three of these squadrons are now equipped with the new F/A-18 Hornet aircraft. The other nine squadrons are scheduled to replace their aging F-4 Phantoms with the F/A-18 Hornet by the end of this decade.

Squadron personnel are assigned by Headquarters, U.S. Marine Corps, based on a "fair share" of available manpower. They are not manned at full Table of Organization (T/O) strength, but rather average 85-90% of the T/O in total numbers. Since the average tour length is three years, each squadron finds itself in a constant state of turnover in both enlisted and officer personnel. Appendix A depicts the Maintenance Department section of the U.S. Marine Corps fighter squadron, according to the

Table of Organization. The augmentees listed are those individuals that are assigned to the squadron but work at the Intermediate Maintenance Activity (IMA) where actual component repair is done. These individuals are responsible for the repair of components for all the fighter squadrons aboard the base/ship. Therefore, they were removed from the data base for this analysis.

During peacetime, a squadron focuses on two primary objectives; training the aircrew to be fully combat ready, and training the maintenance personnel to achieve and keep the aircraft full mission capable (FMC). These objectives encompass the reasons for the constant exercises, deployments, and inspections that a squadron is either preparing for, undergoing, or recovering from. Training is a daily, on-going process in aviation, one that is taken very seriously both in the air and on the ground.

Aircrew (comprised of a pilot and a radar intercept officer (RIO)) are trained in accordance with a very exacting and rigorous syllabus. The manual for this is called the Training and Readiness Manual (T & R). This manual sets up guidelines for each sortie an aircrew must complete. Each completed sortie is worth a percentage value which is credited to the individual's combat rating percentage (CRP). Since each of these training and proficiency flights expires after a specified period of time (normally three to twelve months) it sometimes becomes difficult in a particular month not to lose CRP. This system does provide a good means of evaluating aircrew as well as planning exercises that will test potential areas of weakness.

Maintenance personnel are also in a constant state of training, although not as rigidly defined. Beyond the initial schooling that each perspective mechanic and technician receives after boot camp, there is a steady stream of "on-the-job" training as well as an occasional intermediate level school. Much of the training in the squadron deals with diagnoses and troubleshooting. Additionally, as an individual becomes more senior, he begins to take on more responsibility. He may find himself as a crew leader, work center supervisor, flight line troubleshooter, or Quality Assurance Representative.

As shown in Appendix B, each division is comprised of from one to five individual work centers. A typical division is illustrated in Appendix C. Each work center has a work center supervisor (normally an E6 or above) who is responsible for his work center. The work center, or shop as it is normally called, is task organized around the tempo of operations. Normally the work center is divided into three, eight hour crews. Day crew (0800-1600 hours) has the normal responsibility of launching and recovering aircraft, as well as making quick repairs in support of the daily flight schedule. Night crew (1600-2400 hours) does the majority of the maintenance and extensive troubleshooting on the aircraft. Mid crew (2400-0800 hours) completes any unfinished maintenance and prepares the aircraft for morning launches.

The hub of the maintenance department is maintenance control. Aircraft are assigned for flight by maintenance control, and upon return, the aircraft are assigned to work centers by maintenance control. A very precise and well-defined paperwork flow is outlined in the four volume OPNAVINST 4790.2. Each aircraft is accounted for every hour of the day and is either mission capable (MC) or not mission capable (NMC), as defined in Appendix D. All maintenance performed is documented very carefully and thoroughly. A very simplified version of the decision-making process of a maintenance controller is provided in Appendix E.

It is the Maintenance Data System (MDS) that keeps a record of each aircraft and its status. As maintenance is being performed on an aircraft, its status may change several times. A brief example of this is provided in Appendix F. At the end of each month, statistics are compiled on the squadron as a whole showing the squadron Mission Capable Rate, Full Mission Capable, as well as flight hours, aborts, and a host of other statistical reports. Aircraft data is analyzed in depth and reports are available and distributed throughout the command structure.

Many squadron comparisons are based on mission capable (MC) or full mission capable (FMC) rates. These are often used by the Aircraft Group Commander, as well as higher authority, to measure his squadrons' performance and capabilities. Therefore, there are high incentives to do everything possible to keep the aircraft performance rates as high as possible. The quest for the highest rates possible often has the greatest impact on the decision-making processes of the maintenance department.

III. LITERATURE REVIEW

Any attempt to examine the effect of various inputs on the level of output requires a working knowledge of production functions. Considerable time and effort were expended by Brown and Schwartz in their studies of aviation resources and readiness. Their work included the following four properties of a production function:

> (1) An increase in the level of any input should produce an increase in the level of output.
>
> (2) Subsequent increases in the level of any one input, holding all other inputs constant, should produce smaller and smaller absolute increases in the level of output.
>
> (3) The marginal increase in output resulting from an increase in any one input will be greater if other inputs are also measured.
>
> (4) Many different combinations of inputs can be used to produce the same level of output. [Ref.1: p.7]

In 1977 Horowitz and Sherman [Ref. 2] conducted a study on crew characteristics and conditions of various subsystems aboard ship. The study determined that the average paygrade of the crew and the complexity of the equipment were consistently impacting on the condition of the equipment.

Marcus [Ref. 3] took the production function and utilized it in his work to determine a least-cost mix of personnel, maintaining constant output measures. The analysis was based on Navy A-7 aircraft squadrons using a production function to obtain the demand requirements. Because this approach also gave estimates of substitution elasticities, potential tradeoffs in input variables were readily identifiable.

The model had two versions to it, the first using the number of flights and the second using quarterly mission capable (MC) rate as the output measure or dependent variable. The input or independent variables of his primary model included number of aircraft, number of personnel in grades E1-E3, number of personnel in grades E4-E6, and number of personnel in grades E7-E9. There were several other models examined using breakdowns of skill levels, experience levels, educational groups, and mental groups individually as independent variables.

In general, the study concludes that a least cost force would call for a reduction of eighteen personnel in the grades E1-E3, a reduction of thirteen personnel in the grades of E4-E6, and an increase of seven in the grades of E7-E9. These conclusions were based on using the parameter values obtained from regressing flights on pay grades and then obtaining elasticities.

In several areas this project admitted to finding unpredictable and conflicting results that were unexplainable and dismissed by the author. As the first part of this thesis, the Marine Corps data was used in the model suggested by Mr. Marcus. The results were completely useless with the coefficient of determination being very low (R^2 = .1257). The only variable found to be statistically significant was the number of aircraft.

This model did, however, provide a good starting point for the development of the model proposed by this thesis. It must be emphasized however, that since mission capable and flights make up only a portion of the readiness/productivity of a squadron, they should not be utilized for the purpose of determining least cost, or personnel tradeoffs. Research in this area must include much more detailed data on the impact of an individual on the unit.

Mission capable rates and number of flights do indicate a portion of a unit's productivity or effectiveness but so do many other variables such as training accomplished, number of reported discrepancies, number of aborts, and inflight failures. What percentage of readiness/productivity is captured by each of these variables is unknown. Therefore, until a dependent variable is found that can be proved to fully capture unit productivity/readiness, models are incapable of providing definitive answers concerning least cost structures and mix.

IV. DATA

A. PERSONNEL

The data base that was used for the personnel computations was obtained from the master files at Headquarters, U.S. Marine Corps. Data was requested on all personnel assigned to Marine fighter squadrons as of the 30th of March, June, September and December starting with June 30, 1980 and terminating with 30 March 1985. Data was provided on each of the twelve tactical F-4 squadrons as well as the one training squadron. The data fields are listed in Appendix G.

Billet MOS (BMOS) proved to be of far less value than primary MOS. Initially, it was thought that Billet MOS may identify individuals that may be working in work centers other than those identified by their Primary MOS (PMOS). Upon examination of the data however, it was found that seldom was there a difference, and often BMOS was left blank. Therefore, PMOS was used exclusively in determining an individual's work center.

Time in grade and time in service were selected as further discriminators for experience and expertise and a method of further sorting grades. Because of the problems encountered in the model and the lack of statistical significance computed when incorporated into the model, they were not used.

Time in unit was requested as an indicator of group cohesion and uniformity. It was believed that a unit with a higher average time in unit may achieve higher levels of readiness because of their familiarity with one another and consistent, established routines. Although not listed in a separate field on the Master Files at Headquarters Marine Corps, it was initially believed that this information could be obtained by analyzing Monitor Command Code (MCC) and Reporting Unit Code (RUC) assignments. The resultant field had many entries in excess of 120 months (ten years) and a mean in excess of 48 months (four years). Since a normal squadron tour is thirty-six months, this information had to be disregarded as unreliable.

Time to End of Authorized Service (EAS) was selected as a measure of the "short-timer" and his assumed lower productivity as he nears his end of service. It was also chosen to reflect increased lost work days for release physicals, dental exams, and numerous other administrative tasks that decrease a worker's availability when he decides to leave the service.

The education codes (education level, education major and years of education) were chosen to measure any impact education may have on levels of readiness. They were later discarded because of the amount of time that often transpired between educational experience and records being updated to reflect this acquired education.

Service entrance scores (Armed Services Vocational Aptitude Battery) were selected to give a base or entry level of individuals. This immediately presented several problems. In the 1970's the ASVAB exams replaced the Armed Forces Qualification Tests. Because the personnel involved ranged from six months to twenty-three years of service ASVAB scores were not available on all personnel. Many had enlisted using the AFQT as the entrance exams. Some had enlisted during the ASVAB misnorming problems that occurred in the mid-1970's and these scores had never been corrected from the Marine Corps Master Files. All of these scores therefore were eliminated from the models.

School codes were entered to show the many military schools each individual had attended during his career. All the codes were compiled and divided into two categories: maintenance and formal schooling. Maintenance schools were defined as those that would enhance an individual's ability to perform maintenance on an F-4 aircraft. This division was based on the course description. The schools are listed in Appendix H. All other schools listed were labeled as formal schools and included NCO Leadership School, Embarkation School, Staff NCO Academy and Motor Vehicle Operator School.

B. AIRCRAFT

The aircraft data file was received from Navy Maintenance Support Office Department, the depository of all Navy and Marine Corps aircraft statistical data. Data was collected for all Marine F-4 squadrons from April 1980 through March 1985. Since this data was given in monthly totals, it was totaled and averaged over the relevant quarter to allow it to be merged with the personnel file.

During this period, the F-4 aircraft appeared in Marine squadrons in three models: F-4J, F-4N, and F-4S. The F-4N was dropped from the data base because of its dissimilarity between it and the other two models and also because of its complete phase out by 1983. This reduced the number of squadrons analyzed to ten. The F-4J and F-4S had enough similarity that they were treated as the same aircraft for this study. VMFAT-101, the training squadron, was dropped from the analysis because of the differences in its size and mission. Therefore, the final aircraft data base represented nine squadrons.

There is a wealth of summary data available in this report. A listing of each of the major status codes is computed and recorded in this report along with further subdivisions of these codes. Much of the data available was considered for inclusion as an independent or dependent variable. Most of these measures had to be discarded because of their measurement of a very restrictive portion of squadron readiness/productivity. Other data was disregarded because of the concern over potential manipulation of the data and the misleading analysis that could result.

The number of aircraft during the month was computed by taking the number of hours aircraft are reported as equipment in service (EIS) for the month, divided by the number of hours in the month. This was then averaged for the quarter. The measurements of mission capable (MC) and not mission capable supply (NMCS) are discussed in Chapter V.

V. MEASURING PRODUCTIVITY/READINESS

Readiness is an illusive quality which is often measured differently because of the vast differences in experience levels and backgrounds of those trying to measure it. To compound the problem we must introduce the possibility of "gaming" the measurement. Gaming is the ability to manipulate the measurement so it will produce a more complimentary figure. Many of the readiness measurements are fairly simple to game.

Flight hours are probably the most frequently used measurement for comparison among like squadrons. It is also probably the easiest to game. In a fighter squadron, simply put three external fuel tanks on each plane and have them fly at maximum endurance airspeed and each sortie will generate about 2.5 hours of flight time. The average flight time of a fighter is 1.2 hours. Therefore one squadron can fly half as often during the month yet generate far more hours. Additionally, since the fighter aircraft is not best utilized for most of its missions at maximum endurance airspeed, the aircrew are developing bad habits which could prove fatal in a time of open hostilities.

Sorties or flights is another measurement often utilized. To game this measurement we simply do the reverse of gaming flight hours. We remove all external fuel tanks and we fly at high airspeed. This decreases the flight time dramatically to where the average flight becomes 0.9 hour. This allows the squadron to fly each aircraft more frequently each day. Additionally, if its facility has refueling pits (allowing the aircraft to refuel without shutting down the engines) the squadron will be able to fly each aircraft up to 6 time a day with a minimum amount of maintenance between flights.

Full Mission Capable (FMC) is defined as hours in which an aircraft has all of its associated systems fully operational and capable of performing all assigned missions. Mission Capable (MC) time is defined as hours in which an aircraft is capable of performing at least one of its assigned missions. Both of these measurements are calculated as percentages of the total hours available in a month and aggregated for the entire squadron of aircraft. In theory, this should give a good indication of the mechanical shape of the aircraft.

In practice this is one of the easiest statistics to game. All the figures are computed from squadron documents and are extremely difficult to check for authenticity. There are a variety of schemes available to allow a squadron to select what they want their FMC and, to a lesser degree, MC figures to be. Since the data have an invisible trail and limited audit capability, these measurements are becoming increasingly meaningless. They are, however, still widely used at upper levels for comparison purposes.

Repeat discrepancies are problems that reoccur on the next flight subsequent to maintenance repair. They serve as an indicator of true knowledge of the aircraft systems and thoroughness of the maintenance effort. Unfortunately, these figures too, are tied to squadron generated maintenance documentation thereby allowing the squadron to control the number of repeat discrepancies that actually appear statistically.

A-799 is a code that is used by the Intermediate Maintenance Department (AIMD). The mission of the AIMD is to repair the components that the squadron has removed and replaced with operational components. If a squadron turns in a component that is later found to be operational and without defect it is labeled as A-799 or no defect found. This would seem to indicate that the squadron is guessing at what is wrong with the aircraft or using improper troubleshooting procedures. Since this document is generated outside the squadron, it would seem to give a fairly accurate picture of this area of maintenance.

Gaming this is a little more difficult but not impossible. If a squadron member can cultivate the friendship of an AIMD technician he can often coerce the technician into bench checking the component during his lunch hour or after hours. Since the component has not actually been turned over to the AIMD, no paperwork is generated and so there is no A-799 count.

Safety records in general, and accident-free hours in specific, would seem to evaluate a very important part of squadron readiness. They too, however, are fairly easy to manipulate. On all but the most serious accidents and mishaps, investigations are done using personnel from within the squadron. It therefore becomes very difficult to be completely objective and detached in making an evaluation. Accidents therefore become mishaps which become incidents which become non reportable and the result is a squadron with thousands of accident free flight hours.

Exercises such as missile shoots used to be considered an exceptional measurement of aircrew skills as well as maintenance performance. It was very easy to grade. The missile either fired or it didn't. The missile either hit the target or it didn't. What could be easier to score.

Then the squadrons got wise. If they launched three aircraft instead of two they had a better chance of launching one missile than if they only launched two aircraft. Then they found the critical point in firing the missile. They discovered that if they in fact fired the missile before they told the ground controller to turn the drone, they had an almost 100% chance of destroying the drone and nobody could prove they had launched the missile out of sequence.

Aircrew had a very rigid syllabus that they must complete. Each completed mission in the syllabus has a certain weight factor or percentage tied to it. The goal is to reach 100% which is full combat qualified. Completed missions expire after a certain number of months depending on the difficulty. Therefore, aircrew must fly a certain amount of syllabus hops just to maintain their currency in certain mission specific areas. Each month a squadron reports the increase/decrease on each of its aircrew.

Since these documents are generated by the squadron, they too, are subject to gaming. Since there are no evaluators on most flights, it is up to the individual to determine if he successfully completed the assigned syllabus flight. If there is a push to show a big increase it is not uncommon for a person to take credit for two or three syllabus missions on a single flight. Flights that require an evaluation are done from personnel within the squadron so successful completion is assumed and expected.

Every month each squadron would publish a squadron operations/maintenance plan. In it would be a calendar of the next month with the number of projected flights for each day. This became a good method of evaluating the forecasting capability of the squadron as well as the ability of the squadron to meet a demand, even if it was self-imposed. Many Group Commanders became increasingly aware of the percentage of the number of sorties flown to the number of sorties forecasted.

As this percentage became more popular for evaluation, squadrons found a method to game it. Since the percentage was based on total sorties flown to total sorties scheduled it was found that both these numbers could be easily manipulated. First, the squadrons would underestimate the sorties scheduled on a daily basis. Then, they would write-in or add-on sorties as the day progressed. This meant that they could schedule ten sorties and fly fifteen because of add-ons and they would immediately be five sorties ahead of goal for the month. This led to squadrons achieving 150-200 percent of their goals for the month.

The squadron's abort rate was also often used for comparison purposes. An aircraft was considered an abort if it was assigned to fly a mission and they subsequently broke, either before flying or before completing its assigned mission. When this happened, a code was entered on the maintenance documentation form which labeled the type of abort that occurred. The key here is that the discrepancy is discovered by the aircrew.

It immediately becomes obvious how to game this figure. If a discrepancy is discovered on the ground before or after flight by the aircrew, it is an abort. However, if it is discovered by maintenance personnel, it is coded and displayed as part of the inspection checks. Therefore if maintenance personnel walk around the aircrew on the preflight and postflight inspections and a discrepancy is discovered, if the maintenance personnel writes up the discrepancy it is not listed as an abort. This technique has actually been found to reduce aborts to about fifty percent of what they previously were recorded at.

There are many other readiness measures. Unitrep, aircraft utilization, critical NEC/MOS, personnel staffing, disciplinary actions, and manhours expended are just a few of them. All of these plus those mentioned in greater detail above possess the same basic problem. They all measure a part of aviation readiness but none give alone gives a good reading of overall squadron readiness. So the problem really becomes how to combine some of these measures in such a manner to capture in a model a true and accurate picture of the squadron's readiness.

VI. ANALYSIS

A. MODEL

All of the models discussed in this thesis use Mission Capable (MC) as the dependent variable since it was the best single indicator of readiness/productivity as well as being least susceptible to manipulative measurements.

The first model explored was one of the models suggested by the Marcus study reviewed in Chapter III, using the U.S. Marine Corps data obtained for this study. The data used for this model incorporated data for the entire squadron, not just the maintenance department.

The results using the Marcus model on this data are shown in Table 1. E1-E3 represents the total number of personnel in pay grades E1 to E3 in the squadron. E4-E6 represents the total number of personnel in pay grade E4 to E6 in the squadron. E7-E9 represents the total number of personnel in pay grade E7 to E9 in the squadron. The number of aircraft is computed by dividing the total number of equipment in service (EIS) hours by the total EIS hours available per month per aircraft.

Interaction terms are introduced into a model if it is believed that the difference in the dependent variable for two levels of one independent variable depend on the level of another independent variable. In this model, variable 5 represents the interactions between E1-E3 and E4-E6.

TABLE 1

THE MARCUS MODEL

Variable	Parameter Estimate	t for H0: Para = 0	Prob>|t|
Intercept	34.52	2.67	.0082
(1) E1-E3	-0.64	-1.13	.2581
(2) E4-E6	-0.20	-0.34	.7350
(3) E7-E9	0.48	0.12	.9084
(4) Number of A/C	14.61	2.04	.0433
(5) (1) x (2)	0.11	0.13	.8957
(6) (1) x (3)	3.82	1.67	.0977
(7) (2) x (3)	1.40	0.60	.5526
(8) (1) x (4)	-1.18	-0.38	.7041
(9) (2) x (4)	-0.20	-0.06	.9488
(10) (3) x (4)	-16.62	-1.88	.0622

$R^2=.1257$ Adjusted $R^2=.0754$

Variable 6 represents the interactions between E1-E3 and E7-E9. Variable 7 represents the interactions between E4-E6 and E7-E9. Variable 8 represents the interactions between E1-E3 and number of aircraft. Variable 9 represents the interactions between E4-E6 and number of aircraft. Variable 10 represents the interactions between E7-E9 and number of aircraft.

A t-distribution can be used to test the significance of each of the independent variables. The standard null hypothesis is that each independent variable has no effect on predicting the dependent variable. If, however, the computed t-statistic is greater than the absolute value of two (which infers that it is more than two standard deviations from zero) the estimated coefficient is significant at the 0.05 level. This is the level most often used to show the predictive value of an independent variable on a dependent variable.

It becomes immediately evident from the results in Table 1 that there is not a good fit between this data and the Marcus model. The results of the t-test, for the null hypothesis that each individual parameter is equal to zero, indicate that each of the independent variables is within two standard deviations of zero. This accounts for only one parameter (number of aircraft, .0433) being statistically significant. The adjusted R^2, .0754, (which measures the amount of the variation in the dependent variable that is accounted for by the independent variables) was very low which helped confirm the weakness in the model when applied to these data.

It appeared that the Marcus model was run including all personnel in the squadron. As discussed in Chapter 2, this may be inappropriate for the dependent variable MC. While augmentees are assigned to the unit itself, their contribution to the squadron's mission capable rate is primarily reflected through the two supply categories (PMCS and NMCS) of the system. Since they do not work solely for their squadron, they must be removed from the model.

This was done with the data and the model was rerun with little difference in the outcome. The adjusted R^2 increased to .1070, but again the only independent variable that was statistically significant was aircraft. The Marcus model did, however, provide a good starting point for this thesis. All of the following models are based on the personnel with the maintenance department, exclusive of augmentees and other non-maintenance personnel.

Since pay grade seemed to have little effect in the Marcus model, personnel were sorted into five divisions based on their PMOS and commonality. Division 1 consisted of flight line and ground support personnel. Division 2 consisted of maintenance administration and maintenance control personnel. Division 3 consisted of all airframes division personnel. Division 4 consisted of all avionics personnel. Division 5 consisted of all ordnance personnel.

A variable labeled E1-E5 percentage was included to account for the worker/supervisor ratio. This was computed as the number of E1-E5 divided by the number of personnel in the maintenance department.

Turmoil that occurs when an individual leaves the service may be significant. To measure this, EAS percentage was computed by taking the number of E1-E5 personnel with less than six months to EAS and dividing that by the number of E1-E5 personnel in the squadron.

Formal education was broken down into maintenance schools and non-maintenance schools. Maintenance schools were those schools having a direct bearing on the maintenance of the aircraft and are listed in Appendix H. All other schools listed were categorized non-maintenance schools. Each of these totals was divided by the number of personnel in the maintenance department, which provided an average per person figure for these two categories.

The model shown in Table 2 is the result of a regression using the variables described above. The model demonstrated a relatively high adjusted R^2 (.5910), but had only one significant independent variable. The t-tests show that the independent variables chosen are not closely related to the dependent variable in the model.This model also raises questions about division 5 (ordnance) personnel

TABLE 2

PERCENTAGE OF T/O MODEL

Variable	Parameter Estimate	t for H0: Para = 0	Prob>|t|
Intercept	67.03	3.22	.0016
Division 1 Pct.	21.35	4.38	.0001
Division 2 Pct.	3.53	0.90	.3673
Division 3 Pct.	6.14	0.95	.3428
Division 4 Pct.	10.41	1.37	.1716
Division 5 Pct.	-10.75	-1.76	.0805
E1-E5 Pct.	-16.28	-0.62	.5379
EAS Pct.	4.64	0.67	.5058
Maint. Sch.	-1.42	-0.65	.5183
Non-Maint Sch.	5.94	0.74	.4581
NMCS	-1.62	-10.44	.0001

R^2=.6145 Adjusted R^2=.5910

and their apparent inverse relationship with mission capable. There is no reason to believe that a decrease in ordnance personnel will lead to an increase in MC rate. The model did indicate that breaking down the personnel into five divisions was inappropriate.

A further analysis of the work flow of the maintenance department indicated that much of the work that leads to aircraft becoming mission capable is not the result of any one work center or division but rather is the result of cooperative efforts of all the divisions. Quite often there were several divisions working together to repair one problem.

Another concern was focused on the EAS variable. This measure was initially constructed as a measurement of first term personnel. In including E5's in this computation, the variable was picking up some personnel in their second enlistments. To ensure a measurement of only first-termers, this variable was subsequently redefined to include only E1 to E4 personnel. The time to EAS was redefined from six months to four months. This was based on the observation that most of the lost work time due to administrative and medical matters occurs during the final four months.

A Cobb-Douglas production function was proposed as an alternative to the linear additive model used above. This model allows an examination of a non-linear model, one in which the independent variables have a multiplicative impact on MC rather than an additive impact. In this model the marginal product of each input will always be positive, but diminishing. However, returns to scale may be increasing, constant, or decreasing. The model permits interactions among the independent variables. The marginal product of each input depends not only on the utilization of that input, but also on the levels of the other inputs. For example, this model captures the increased flexibility a squadron enjoys as it acquires additional aircraft (illustrated in Appendix E).

A Cobb-Douglas production function can be estimated using linear regression by applying a log transformation to all of the variables. The result is an equation that expresses the log of MC as a linear function of the logs of the independent variables.

The log-linear model is displayed in Table 3. The results indicate a much stronger relationship between these independent variables and the dependent variable, log MC. More of the parameter tests are statistically significant than on any of the previous models. This indicates a more appropriate functional form and better predictive value for the independent variables. The level of significance improved for all variables and the adjusted R^2 remained above 0.55.

TABLE 3

LOG LINEAR AIRCRAFT MODEL

Variable	Parameter Estimate	t for H0: Para = 0	Prob>|t|
Intercept	2.51	4.38	.0001
Log E1-E5	0.38	4.09	.0001
Log E6-E9	0.13	1.60	.1111
Log E1-E4 EAS	0.03	2.51	.0131
Log Maint. Sch.	-0.30	-3.68	.0003
Log Non-Maint. Sch.	0.15	1.97	.0512
Log NMCS	-0.13	-9.78	.0001
Log Aircraft	-0.01	-1.15	.2529

R^2=.5722 Adjusted R^2=.5533

One troubling result of this model is the negative effect of aircraft. This may be somewhat explained by the nearly absolute maximum limit of twelve aircraft per squadron. The constraint on this variable may distort its relationship with MC.

A simple linear version of the above model was estimated, with the results shown in Table 4. Several things stand out immediately. First is the fact that of the seven independent variables, only two fall inside the two standard deviation criterion. Both of these are much closer to statistical significance than achieved on previous models. This would indicate a model that has independent variables with a closer relationship to the dependent variable. The adjusted R^2 climbed to .5806. The results indicated that this is a good beginning model for this type of analysis.

B. ANALYSIS

Because mission capable (MC) appears to be least susceptible to interpretive measurements, as discussed in Chapter V, it was selected as the dependent variable. It is one of the measures of a squadron's productivity/readiness that is closely monitored throughout Marine Corps aviation. Although masking many individual squadron strengths and weaknesses, it does reflect the material condition of the squadron's aircraft. For this study the mean or average

TABLE 4

THE LINEAR AIRCRAFT MODEL

Variable	Parameter Estimate	t for H0: Para = 0	Prob>|T|	Elasticity at the Mean
Intercept	41.83	4.15	.0001	
E1-E5	0.18	3.85	.0002	0.32
E6-E9	0.39	2.25	.0260	0.17
E1-E4 EAS	22.48	2.48	.0140	0.03
Maint. Sch.	-5.21	2.47	.0142	-0.17
Non-Maint. Sch	14.05	1.70	.0920	0.12
NMCS	-1.63	-10.33	.0001	0.09
Aircraft	0.62	1.75	.0825	-0.14

R^2=.5984 Adjusted R^2=.5806

value of MC was found to be 72.2 percent with a standard deviation of 11.36.

Quantity of personnel contributes significantly to MC. However, the contribution of an E3 is not the same as the contribution of an E7. Each is a contributor but in very different, unique roles. For this reason personnel were divided into workers and supervisors. This is not to infer that E6's and above do not perform any aircraft maintenance but rather to acknowledge their responsibilities as supervisors and managers. A worker's value lies in his ability to repair aircraft efficiently and effectively. The supervisor's value is more in the coordination of his personnel and any extensive troubleshooting that may be required. Both impact MC but each has a separate and distinct role to play. Their value then should be computed separately. The mean value of E1-E5 personnel in the maintenance department was 129.92 with a standard deviation of 12.890. The mean or average value of E6-E9 personnel in the maintenance department was 31.24 with a standard deviation of 4.13.

It must be emphasized that this model focused on the maintenance department. Therefore, personnel assigned to the squadron but not the maintenance department were removed from the data. These personnel included those in administration, operations, logistics and all augmentees. Rerunning the model with all squadron personnel included in the data base proved to significantly weaken the model. The difference in the coefficient of determination (R^2), which measures the proportion of the total variation in the dependent variable explained by the model, decreased more than five percent for the model including all personnel. This fact, combined with the belief that the contribution of these non-maintenance personnel is in areas other than MC, substantiates omitting them from a model which uses MC as the dependent variable. Since this analysis focused on MC, personnel not in the squadron maintenance department were removed from the personnel data base.

An individual's productivity is influenced by many factors. As a worker approaches the time where he may be making a vocational change, his measured productivity has a tendency to decrease because of the additional constraints on his time. In the case of the military, this decreased productivity is heightened by such things as administrative, medical and dental requirements prior to release. Additionally, in many cases, individuals are shuffled to other units due to the individual's non-deployable status. Since squadrons are constantly building for the future, decisions regarding responsibilities, training, and rewards are often made ignoring those "short-timers" who are or may be terminating soon.

The independent variable EAS captures this situation. It measures the percentage of all E-4 and below (first termers) that have an end of active service (EAS) of four months or less. This variable is a rough representation of squadron turmoil due to attrition. The mean value was 9.76 percent with a standard deviation of 6.43 percent.

Formal education was divided into maintenance and non-maintenance schools. All military schools contribute to MC for a variety of reasons beyond a direct benefit of increased maintenance skills. Leadership skills, organizational skills, qualifications in motor transport all have an effect on MC. Since school quotas are often difficult to obtain, there is often a tight screening process within the squadron to determine who will attend. This factor may allow these variables to indicate a measure of quality of personnel as well as military education background. The mean or average value of maintenance schools was 2.38 per man with a standard deviation of 0.30, while the mean or average value of non-maintenance schools was 0.61 with a standard deviation of 0.09. It must be noted since all maintenance personnel attend a school to qualify for their PMOS, each person starts with a base of at least 1 in maintenance schools prior to arriving at his first squadron.

Not Mission Capable Supply (NMCS) was included to represent the percentage of time in which a squadron is incapable of returning an aircraft to a mission capable status. If a replacement part is unavailable, the squadron can either try to cannibalize the needed part from another NMC aircraft (usually a poor choice) or wait for the part to arrive. The mean or average value was 6.06 with a standard deviation of 4.07. This means that these squadron's were averaging 6.06 percent of their monthly time with non-flyable aircraft because of non-availability of parts.

Since MC is measured from the total EIS for the squadron (see Appendix D), the number of aircraft becomes significant. Flying an aircraft too many hours per month results in an increase in the number of maintenance hours per flight hour. The opposite of this is also true. Not flying the aircraft results in a lack of reliability of the aircraft as it becomes more susceptible to dried and cracked seals. An aircraft that flies infrequently is also statistically more prone to abort a mission. Too few aircraft often results in overflying some of them which nearly always results in an increase in down time and aborts in later months. Too many aircraft results in a backlog of maintenance. Although squadrons are nearly always assigned twelve aircraft, this number is in a constant state of flux due to aircraft modifications, depot-level maintenance, and any extensive repair work that requires specialists. The mean value for aircraft was 10.29 with a standard deviation of 1.73.

The coefficient of determination (R^2) for the model presented in Table 4 shows that nearly 60% of the total variation in MC is explained by this model. Using a statistical significance of 0.05, the model shows all the independent variables except non-maintenance school ($P = .0923$) and aircraft ($P = .0649$) to be statistically significant. This means that these two variables do not have as great a predictive value as the other independent variables. They are, however, very close to the 0.05 level chosen for this study.

The parameter estimates all tend to react as would be expected except for the variables EAS and maintenance schools. The model shows an expected increase in MC for independent increases in either category of number of personnel or an increase in aircraft or non-maintenance schools. It also shows the negative impact on MC of an increase in NMCS.

The EAS variable has several contradictory features that may have resulted in the illogical conclusion that more "short-timers" leads to an increase in MC. The term measures those that may be leaving active service shortly. It does not, however, record how many of them actually re-enlisted or extended. If the number of reenlistments of first term personnel was significant in any given period, this variable would be mixing those that re-enlisted (proven performers with probable high motivation) with those choosing to leave (poor performers as well as those choosing a vocational change). These factors could certainly tend to cause this variable to become inaccurate and misleading.

The variable that measures maintenance schools likewise has a plausible but hidden explanation. Since all maintenance personnel have attended at least one of these schools (which qualifies him or her for a PMOS) prior to arriving at the squadron, they are actually starting with a base of one rather than zero (like non-military schools). What this negative value may be describing is the result of too much formal schooling. While it is acknowledged that the purpose is to increase the productivity of the individual, the cost is the loss of the individual during the training. Thus we see non-maintenance schools having a positive impact on MC and we would expect to see a positive impact on maintenance schools as well. However, because of the inflated mean for maintenance schools (2.38) the resultant negative impact on MC may well be magnifying the loss of productivity.

The elasticities of the means given in Table 4 provide an interesting insight. A ten percent increase in the number of E1 to E5 personnel would statistically provide a 3.2 percent increase in MC. A ten percent increase in the number of E6 to E9 personnel would statistically provide a 1.7 percent increase in MC. It would take nearly a twenty percent increase in the number of E6 to E9 personnel to have the same effect as a ten percent increase in E1 to E5 personnel. A ten percent increase in E1 to E5 personnel is approximately thirteen whereas a twenty percent increase in E6 to E9 personnel is six. Deriving what mix would be most cost effective is beyond the focus of this thesis. However, because MC is a component of unit readiness/productivity the derivation of personnel mix would be accurate only to the point where MC is an accurate measurement of unit readiness/productivity.

C. SUMMARY OF DATA ANALYSIS

The model presented gives hope to the possibility of regression models becoming more accurate in assisting manpower policy decisions. This model acts as predicted and in the two variables that produced results contrary to those expected (EAS and maintenance schools), it is believed that further purification of these variables would result in not only predictable results but also an increase in the R^2 value of the model.

VII. CONCLUSIONS

This study is a very elementary, big picture analysis. It was designed to show that a mathematical relationship could be developed to draw general conclusions about personnel characteristics and measures of readiness or productivity. Since the dependent variable used is a generalization of a single aspect of a squadron, the results cannot be used to make specific recommendations concerning optimal size or composition of a squadron.

This model falls short of expectations due to a lack of personnel data that may have proved to have been very beneficial in expanding the model. It is believed that the addition of several independent variables would strengthen this model dramatically.

Each individual should be measured for the amount of time, in months, he or she has spent in the squadron. An average value could then be computed for the squadron. This average would equate to a measure of unit cohesiveness, known to increase productivity.

A quarterly reenlistment index could be developed which would be an indicator of squadron morale. Job satisfaction results in increased retention and increased productivity. High morale has the same results. Both of these are measured, to some degree, by reenlistment figures.

Just as the number of aircraft affected MC, the number of aircrew assigned and average flying time in months would prove to be an asset to this model. The more aircrew that are available results in more flying because of increased competition for the aircraft. It would be predicted that a higher average total flying time (experience) of the aircrew would result in better discrepancy write-ups by the aircrew as well as better inflight diagnosis of any aircraft peculiarities. These accurate debriefs would result in fewer repeated discrepancies, as well as less required troubleshooting time, increasing MC.

Dummy variables could be inserted for special periods of extremely high operational commitments. Additionally, controls for holidays, periods of non-flying, and adverse weather could likewise be inserted into the model.

An entire model could be built around the codes for awaiting maintenance, particularly if the model was designed to examine a specific work center or division. At that point, comparisons of quantity and quality of personnel can be made because the dependent variable (manhours, for example) would reflect only the independent variables from within the unit. It is on this level of analysis that impact of workers and supervisors becomes better defined and the experience level of personnel can be brought more to bear on the model. This type of model may demonstrate the impact of an additional supervisor as well as what the proper ratio should be.

As models become more refined and data becomes more accurate, productivity and readiness models can be added to what has already been developed in determining the cost of an unfilled billet. At that point the cost of the unfilled billet will cease to be merely the compilation of the getting an individual to a specific billet with a specific background. Only then can the military demonstrate the full ramifications of personnel cutbacks or decreased reenlistments.

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APPENDIX A

TABLE OF ORGANIZATION

(Aircraft Maintenance Department)

Department/Work Center	Grade	Quantity	Subtotal
Maintenance Admin	E6	1	
	E5	1	
	E4	1	3
Maintenance Control	E8	1	
	E7	1	
	E6	3	
	E4	1	
	E3	1	7
Quality Assurance	E7	1	
	E6	5	
	E4	1	7
Airframes Branch	E7	1	1
Hydraulics	E7	1	
	E6	2	
	E5	5	
	E4	5	
	E3	7	20

Department/Work Center	Grade	Quantity	Subtotal
Metal	E6	1	
	E5	1	
	E4	3	
	E3	7	12
Corrosion Control	E5	1	
	E4	1	
	E3	1	3
Power Plants	E7	1	
	E6	1	
	E5	1	3
Flight Equipment	E6	1	
	E5	1	
	E4	2	
	E3	1	5
Safety Equipment	E6	1	
	E5	1	
	E4	3	
	E3	4	9

Department/Work Center	Grade	Quantity	Subtotal
Ordnance	E8	1	
	E7	1	
	E6	1	
	E5	1	
	E4	6	
	E3	8	18
Avionics Division	E8	1	1
Communication/Navigation	E7	1	
	E6	2	
	E5	4	
	E4	2	
	E3	2	11
Electric	E7	2	
	E6	2	
	E5	4	
	E4	5	
	E3	6	19
Radar	E7	1	
	E6	1	
	E5	5	
	E4	4	
	E3	6	17

Department/Work Center	Grade	Quantity	Subtotal
Flight Line	E7	1	
	E6	1	
	E5	3	
	E4	6	
	E3	13	24
Ground Support Equipment	E5	1	
	E4	1	
	E3	1	3
Total	E8	3	
	E7	11	
	E6	22	
	E5	29	
	E4	41	
	E3	57	163
Augmentees			
Material Control	E7	1	
	E4	1	
	E3	2	4
Data Analysis	E3	1	1

Department/Work Center	Grade	Quantity	Subtotal
Communication/Navigation	E5	2	
	E4	3	
	E3	3	8
Radar	E7	1	
	E5	1	
	E4	3	
	E3	5	10
Electrical	E5	1	
	E4	3	
	E3	5	9
Power Plants	E6	1	
	E5	1	
	E4	3	
	E3	3	8
Metal	E5	1	
	E4	1	
	E3	1	3
Hydraulics	E6	1	
	E5	1	
	E4	1	
	E3	2	5

Department/Work Center	Grade	Quantity	Subtotal
Flight Equipment	E5	1	
	E4	1	
	E3	1	3
Safety Equipment	E5	1	
	E3	1	2
Ground Support Equipment	E5	1	
	E4	5	
	E3	3	9
Ordnance	E4	1	
	E3	2	3
Total Augmentees	E7	2	
	E6	2	
	E5	10	
	E4	22	
	E3	29	65
Total Maintenance Dept	E8	3	
	E7	13	
	E6	24	
	E5	39	
	E4	63	
	E3	86	228

APPENDIX B

MAINTENANCE DEPARTMENT ORGANIZATION

The Maintenance Department comprises the largest number of personnel in a squadron. It is organized in accordance with OPNAVINST 4790.2 and is presented in an abbreviated form in Figure 1.

```
               ----------------------------------------
               ¦ Aviation Maintenance Officer (O-4) ¦
               ----------------------------------------
                                 ¦
            ----------------------------------------------
            ¦ Asst. Aviation Maintenance Officer (LDO) ¦
            ----------------------------------------------
                                 ¦
          ¦--------------------¦-------------------¦
----------------------           ¦       ------------------------
¦ Quality Assurance ¦            ¦       ¦  Maintenance Admin. ¦
----------------------           ¦       ------------------------
                                 ¦
                                 ¦
                     ------------------------
                     ¦ Maintenance Control ¦
                     ------------------------
                                 ¦
                                 ¦
      ¦----------------¦----------------¦----------------¦
--------------    ------------    --------     ------------
¦ Airframes ¦    ¦ Avionics ¦    ¦ Line ¦     ¦ Ordnance ¦
--------------    ------------    --------     ------------

+ Power Plants    + Electric      + Flight Line

+ Metal           + Com/Nav       + Ground Support

+ Hydraulics      + Radar

+ Flight Equipment

+ Safety Equipment
```

Figure 1: Department Organization

The Aviation Maintenance Officer (AMO), is a Naval Aviator or Radar Intercept Officer tasked with the responsibility of the Maintenance Department. In almost every case, he has attended an extensive, demanding school which has given him the additional MOS designation 6002, Aviation Maintenance Officer. In addition to this school, he has normally had assignments as a division officer while serving in a squadron as a lieutenant or captain.

The Assistant Aviation Maintenance Officer (AAMO), is normally a Limited Duty Officer (LDO) who has started out his career as an enlisted man and has subsequently been commissioned. He is not an aviator and thus is able to devote his entire time and energies to the maintenance department and its challenges and problems.

Quality Assurance is staffed by personnel from each of the divisions. Their assignment to this division is based on their experience and maturity. In addition to running many of the maintenance performance monitoring systems, they are required to perform inspections on critical components that have been repaired.

Maintenance Administration personnel are school trained and designated (6046). They have the responsibility of maintaining the various logbooks and extensive records that are required on each aircraft. Much of their work is clerical in nature.

Maintenance Control is the hub of the maintenance department. All maintenance is coordinated by them and all paperwork originates with them. Run by an LDO similar in qualifications to the AAMO, he too, is not an aviator and can focus full time on the maintenance department. Also in this devision is a very senior Master Sergeant (E-8) who has 18 to 20 years of maintenance experience behind him. Additional personnel to staff this division come from the various work centers within the maintenance department.

The Airframes Division is comprised of five work centers: power plants, metal shop, hydraulics, flight equipment, and safety equipment. Headed by an aviator or Radar Intercept Officer, this is the largest division within the maintenance department. This is the only major division that does not have a Limited Duty Officer assigned to it by the Table of Organization (T/0).

The avionics division is comprised of three work centers: electrical communication/navigation and radar. This division has an Avionics LDO in charge and a division chief assigned by T/O. This division is the most technical in nature and therefore carries a larger proportion of sergeants and Staff NCOs than any other division.

The line division is comprised of the flight line and ground support equipment. This division usually has a senior lieutenant or junior captain as the division officer and rates an E-7 as the division chief. Chiefly responsible for the launching and recovery of aircraft, this division carries a high percentage of junior enlisted personnel.

The ordnance division is comprised of ordnance personnel. By T/O it has an LDO as the division officer and an E-8 as the division chief.

APPENDIX C

MAINTENANCE DIVISION ORGANIZATION

Each division is arranged similarly despite differences in composition and responsibilities. Figure 2 presents the normal layout of a division and its chain of command. The division may be organized differently depending on the operational requirements.

```
                          ---------------------
                          | Division Officer |
                          ---------------------
                                    |
                           -------------------
                           | Division Chief |
                           -------------------
                                    |
                       ---------------------------
                       | Work Center Supervisor |
                       ---------------------------
                                    |
              ---------------------------------------------
              |                     |                     |
       ---------------       ---------------       ---------------
       | Crew Leader |       | Crew Leader |       | Crew Leader |
       ---------------       ---------------       ---------------
              |                     |                     |
        ------------         -------------           ------------
        | Day Crew |         | Night Crew |          | Mid Crew |
        ------------         -------------           ------------
```

Figure 2: Typical Division Organization

Each division has an aircrew or an LDO assigned as the division officer and an E7 or E8 as the division chief. Each of the work centers has a work center supervisor assigned to it (normally an E6 or E7). He is responsible for the working of his work center, assignment of details, assignment to work shift, and anything else that pertains to his work center. Each of the three crews (the maintenance cycle is normally worked on a twenty-four hour day) is run by a crew leader who is normally an E6 or E5. The crew leader is responsible for the assignment of his personnel to the specific jobs and priorities that have been assigned to it by maintenance control. He is often a worker as well as a manager and does much of the required inspection of maintenance performed. Additionally, he is responsible for ensuring all the paperwork is properly recorded and annotated on the various forms required.

APPENDIX D

AIRCRAFT STATUS CODES

A squadron is responsible and accountable for the status of each of its aircraft twenty-four hours a day. Therefore, in a thirty day month the Equipment In Service (EIS) hours of each aircraft would be 720 (24 hours x 30 days). In a thirty-one day month the EIS would be 744.

1. Mission Capable (MC). MC is that percentage of EIS hours in which an aircraft is mechanically of performing at least one of its assigned missions (for example, if the radar was not operational, the aircraft could still perform one of its bombing missions). This status can be subdivided into:

   1A. Full Mission Capable (FMC). FMC is that percentage of EIS hours in which an aircraft is mechanically capable of performing all of its assigned missions (all systems fully operational).

   1B. Partial Mission Capable (PMC). PMC is that percentage of EIS hours in which an aircraft is mechanically capable of performing some, but not all, of its assigned missions. This can be further divided into:

1B1. Partial Mission Capable Maintenance (PMC(M)). PMC(M) is that percentage of EIS hours in which an aircraft is PMC and maintenance is either being performed or could be performed.

1B2. Partial Mission Capable Supply (PMC(S)). PMC(S) is that percentage of EIS hours in which an aircraft is PMC and replacement parts had been ordered but not received.

2. Not Mission Capable (NMC). NMC is that percentage of EIS hours in which an aircraft is incapable of performing any of its assigned missions (for example, an aircraft without one of its basic, required instruments, e.g. attitude direction indicator). This category can be subdivided into:

2A. Not Mission Capable Maintenance (NMC(M)). NMC(M) is that percentage of EIS hours in which an aircraft is NMC due to unscheduled maintenance.

2B. Not Mission Capable Supply (NMC(S)). NMC(S) is that percentage of EIS hours in which an aircraft is NMC due to parts on order.

This is a simplification of the MDS status system and omits several subcategories not germane to the material presented in this thesis. Based on the above definitions, the following formulas would exist:

$MC = FMC + PMC$

$100\% = MC + NMC$

$NMC = NMC(M) + NMC(S)$

$PMC = PMC(M) + PMC(S)$

APPENDIX E

MAINTENANCE CONTROL DECISION-MAKING PROCESS

This example begins with an aircraft that was FMC when it was launched, returns from flight.

I. Is it still FMC?

  A. Yes - Prepare it for another flight (FMC).

  B. No - Go to Question II.

II. Is the aircraft PMC?

  A. Yes. A/C is now reportable PMC(M).

    1. Is the A/C needed for daily commitments?

      a. Yes - Prepare for flight PMC(M).

      b. No - Troubleshoot the discrepancy.

        1) Does it need parts?

          a) no - Repair to FMC

          b) Yes - order parts

            (1) Are parts available?

              (a) Yes Repair aircraft to FMC status.

              (b) No A/C is now PMC(S)

                i) Perform other maintenance?

                  - Yes, begin maintenance.

                  - No, prepare for flight PMC(S)

  B. No. Go to question III.

III. This A/C is not flyable. It is now NMC. Does it need parts?

A. No - repair to FMC status.

B. Yes - order parts.

  1. Are parts available?

    a. Yes - Repair to FMC status.

    b. No - A/C is NMC(S).

      1) Is there other maintenance to be performed?

        a) Yes - Perform maintenance

        b) No - Can the part be economically removed from another A/C that is estimated to remain down for an extended period of time?

          (1) Yes - Remove part and return one aircraft to FMC status.

          (2) No - A/C remains NMC(S)

This is a very simplified view of the decision-making process that takes place every day in maintenance control. Often aircraft return with an assortment of PMC and NMC discrepancies that immediately complicate the above procedure. Manpower constraints, scheduled maintenance deadlines and operational commitments must be taken into consideration. In all cases, an aircraft that had both PMC and NMC would be carried as NMC. Skillful planning and coordination can enable PMC discrepancies to be corrected while an aircraft is NMCS allowing for an aircraft to go from NMC to FMC status.

APPENDIX F

DISCREPANCY CYCLE

Perhaps the easiest way to understand how time is computed and categorized is to follow a typical discrepancy and maintenance cycle.

TIME	EVENT	ACTION	REPORTED
0800	Discrepancy reported	Awaiting maintenance	Maintenance (NMCU)
0900	Work started	Elapsed Maintenance Time (EMT)	Maintenance (NMCU)
1000	Work stopped for parts shortage	Awaiting maintenance (AWM)	Maintenance (NMCU)
1100	Ordered parts	Awaiting parts (AWP)	Supply (NMCS)
1500	Parts Received	Awaiting Maintenance (AWM)	Maintenance (NMCU)
1600	Began installation	Elapsed maintenance time (EMT)	Maintenance (NMCU)

TIME	EVENT	ACTION	REPORTED
1700	Work completed		Full Mission Capable (FMC)

AWAITING MAINTENANCE CODES

1. Support Equipment.
2. Hangar, Hangar Deck Spaces, Facilities,
3. Backlog, excessive workload.
4. Offshift Hours (Week-ends, holidays etc).
5. Other - weather, drill, parades, etc.
6. Awaiting AIMD - return of an engine
7. Flight Operations.
8. Awaiting other shops or maintenance actions.

APPENDIX G

PERSONNEL DATA FIELDS

Data Element	Length
ASVB-AD	2
ASVB-AI	2
ASVB-AR	2
ASVB-AS	2
ASVB-CA	2
ASVB-CC	2
ASVB-CE	2
ASVB-CM	2
ASVB-CS	2
ASVB-DAR	2
ASVB-DSP	2
ASVB-DWK	2
ASVB-EI	2
ASVB-GI	2
ASVB-GS	2
ASVB-MC	2
ASVB-MK	2
ASVB-NO	2
ASVB-PC	2
ASVB-SI	2
ASVB-SP	2

ASVB-WK	2
Billet MOS	4
Education Level	1
Education Major	2
Ethnic	1
GT-GCT	2
Monitor Command Code	3
Period	6
Primary MOS	4
Race	1
Reporting Unit Code	5
School Code	3
School Year	2
Sex	1
Time to EAS	3
Time in Grade	3
Time in Service	3
Time in Unit	3
Years of Education	2

APPENDIX H

MILITARY SCHOOLS

Code	Description
A2G	Avionics Corrosion Control
A2S	F-4J/F-4B/or RF-4B Electrical Systems
A2T	Compact Wire Bundle
A4R	AN-AWG 10A Basic
A5E	F-4/RF-4 Armament System
BEW	Weapons Support Radar Maintenance
BE2	Cryptographic Equipment TSEC/KG-22 Maintenance
B0H	Explosive Ordnance Disposal Land Refresher
B0I	Explosive Ordnance Disposal, Conventional Weapons Disposal Indian Head
B0J	Explosive Ordnance Disposal, Basic
B0S	Explosive Ordnance Disposal Refresher, Surface
B07	Conventional Ammo And Explosive Safety
C00	Non-Destructive Inspection Specialist
C01	Non-Destruction Inspectiin
D0M	Data Processing Equipment Operator
EHT	Fundamentals Of Digital Logic
E2D	Microminiature Elec Circuit Repair
FDA	Aircraft Maintenance Officer
FDF	Aircraft Maintenance Officer Phase IV (C-4D-2010)
FFA	Aviation Electronics Indoctrination

Code	Description
M4E	Work Center Supervisor
M8B	Maintenance Control
M9A	Quality Assurance
M9C	Aviation Fundamentals (All 6xxx MOS'S)
NAB	Sealed Authentication Sys - Emerg Action Proc
RBW	Weapons Systems
T04	Aircraft Engineer And Maintenance
T1K	Factory Trng And Related Systems F-4/RF-4
T56	Weapons Employment Familiarization
T63	Marine Aviation Supply Advanced
XRZ	Maintenance Management Information Systems
X9J	Instructor Class C Course A Basic
X9K	Aviation Fundamental Class P School
X9U	Management Analysis Course, Naval Aviation Officer School
X9Z	TSEC/K1-1A Crypto Maintenance
X94	TSEC KI-1A Unlimited
X95	TSEC/KY-28 Unlimited
0DF	Maintenance Management
0DM	Maintenance Management Officer
0DU	KY-28/KI-1A Limited Maintenance
01E	Administration Basic
017	RPS Custodian Procedures
04E	Integrated Logistics Support Management

Code	Description
11B	Electrician Basic
11D	Refrigeration Mechanic
11G	Electrical Equipment Repair
11S	Basic Electricity And Electronics - Aviation Electricians Mate
11T	Basic Electricity And Electronics - Aviation Non Navy
11U	Basic Electricity And Electronics - Avionics Repairman
131	Metalworker
132	Basic Metal Worker
136	Marine Cryogenics Equipment Technician
137	Marine Mechanical Fundamentals School Class D
23A	Ammunition Technician Basic
23C	Ammunition Storage
24N	Communication Security Material System - Basic
249	Technician Electronic Counter Counter-Measures
25J	Electronic Countermeasures Operation
259	Electric & Electronic Measurements (Enlisted)
26X	Crypto Maint., KY-28 Limited
27V	Radio Fundamentals
27X	Radar Fundamentals
27Z	Integrated Fire Control Elec Repair
272	Electronics Basic

Code	Description
28A	KY-8/28/38 Maintenance
28U	SR MIL Crypto Supere (CY 200) (Formerly Senior MIL Crypto Super)
30B	Marine Aviation Supply Class C
30C	Procurement Supply Trainiing
309	Marine Aviation Supply Senior Enlisted Management (Formerly AVN Supply (Enl))
38D	AN/AJB-7 Attitude Reference Bomb Computer And AN/ASN-70A Vertical Flight Reference Set IMA (C-602-3828)
38E	MK-36-40 Destructor/ALL MODS (C-646-3107)
39D	Digital Equipment Switching Technician
39S	Digital Computer Fundamentals (YXC) (C-000-3178)
409	Computer Programming Orientation
414	Fleet Analysis And Reporting (Redesig From Analysis/Reporting)
464	Precision Measuring Equipment
61B	Maint Management And Info Systems
614	F-4B/J/N Aircraft Egress And Evironmental Control System
62B	Aviation Support Equipment Electrical Technician YDH (C-000-3263)
62P	Individual Material Readiness List Managers OMA And IMA (C-500-3202)

Code	Description
62R	Aeronautical Technical Publications Library Management OMA And IMA (C-500-3205)
623	Avionics Corrosion Control (C-000-4176)
624	Micro-Miniature Module Supervisors IMA (C-100-3193)
63B	AN/ALF-29A Countermeasures Chaff Dispenser Set IMA (BQM)
63C	AN/APX-64 (V) IFF Transponder Set IMA (BXA) (C-102-3065)
63K	AN/ALQ-100 Countermeasures Set IMA (BRB) (C-102-3074)
63V	Hydraulic Fundamentals (YXF) (C-000-3180)
63W	Indications And Warning Course
63X	Aviation Fundamentals Aviation Structures Mechanic Hydraulics
63Y	Miniature Component Repair YXH (C-000-3182)
63Z	F-4 Corrosion Control OMA (C -000-3196)
630	LEAR MA-1 Compass Systems IMA (BMB)
631	AN/APN-154 (V) Radar Beacon IMA (BNB)
633	AN/APN-141 (V) Radar Altimeter IMA (BNF)
634	AN/ARN-52 (V) Tacan Receiver IMA (BCN)636
636	AN/APN-171(V) Radar Altimeter (High Level) IMA (BNK)
638	AN/ASN-39/39A And AN/ASN-41 Navigational Computer

Code	Description
64B	Aviation Machinists Mate J Jet Engine B
64H	Aviation Structural Mechanic Metalsmith
64K	Aviation Structural Mechanic Structures B
64L	Aviation Structural Mechanic H Hydraulic A
64M	Aviation Structural Mechanic H Hydraulic B
64P	Aviation Machinists Mate B
64R	Aviation Structural Mechanic E Safety Equip A
64S	Aviation Structural Mechanic E Safety Equip B
64X	Aviation Welding
640	Aviation Material Management
641	Aviation Familiarization
642	Aviation Mechanical Fundamentals A
643	Marine Aviation Engineering Clerical C
644	Aviation Maintenance Administration Man
645	Data Analysis Class C-1
646	Aviation Support Equipment Technicians
647	Aviation Support Equipment Technicians Electrical ASE A
648	Aviation Support Equipment Technicians Mechanical ASM A
649	Aviatiin Support Equipment Technicians Hydraulic ASH A
65A	Aviation Ordnanceman A
65B	Aviation Ordnanceman B

Code	Description
65E	F-RF-4B/J Aircraft System Familiarization Enlisted (FKB)
65R	AN/ARC-51/51A AN/ARC-51AX/51B RT 793/ASQ RT-1010/ASQ-140 Communication sSystems IMA (BCB)
66A	Aviation Electronics Technician Navigation
66B	Aviation Electronics Technician R Radar A
66C	Aviation Fire Control Technician F Fire CNTL A
66D	Avionics Intermediate
66H	Aviation Radar Repair
66R	Aicraft Maintenance Non-Destructive Inspection, Class C
66S	Data Systems Analyst, Class A
66U	Aviation Radar Repair Course A
66Y	Avionics Repairman
66Z	Aircraft Battery Mainteenance And Repair IMA
660	Avionics Technician, Class A
661	Avionics Fundamentals
662	Aviation Fire Control Tech Inter B AQ1
663	Avionics Advanced, Class B
664	Aviaton Fire Control Technician
665	Advanced First Term Avionics Class A-1, Non-Navy
666	Aviation Electricians Mate A
667	Aviation Electricians Mate B
668	Aviation Electrician Mate Class B Intermediate AE

Code	Description
669	Aviation Electricians Mate Advanced
67M	Air Controls Electronics Operator
67S	Aviation Fundamentals Aviation Ordnance
67T	Aviation Ordnanceman Class C7
67W	Aviation Fundamentals Aviation Structures Mechanics Metalsmith
67X	Aviation Fundamentals Avionics
67Z	Aviation Fundamentals Aviation Electrician
681	Aviation Fundamentals Aircrew Survival Equipmentman
682	Aviation Fundameentals Aviation Structures Mechanics Safety Equipment
683	Aviation Structural Mechanic Safety Equipment Course Class C7
69C	Basic Corrosion Control
69D	F-4 Corrosion Control
69P	J-79-GE-8/10 Power Plants
69Z	F-4B/J RF-4B Airframes Maintenance FLR
71A	Aircrew Survival Equipmentman, Class A
71B	Parachute Rigger Maintenance Class A
71C	Parachute Packing Maintenance And Aerial Delivery
71E	Aircrew Survival Equipmentman, Class C7
732	AN/AJB-3A Loft Bomb Release Component Set IMA
87H	F-4B/N CNI-ECM OMA (FEV)

Code	Description
87J	F-4J CNI-ECM OMA (FEV)
87T	AN/ARN-91 Tacan Navigational System IMA (AYM)(AV-8A)
875	AN/ALQ-92 Countermeasures Set IMA (BRC)
880	AN/ALR-45 Countermeasure Rceiving SET IMA (BQH)
887	AN/ARC-114 FM Communication/Navigation Set IMA (BCZ)
89G	Principles Of Management Course
89H	Naval Aviation Maintenance Program Work Center Supervisor (YMB)
89J	Naval Aviation Maintenance Material Control (YMC)
89K	Aviation Maintenance Management (YME)
89L	Naval Aviation Maintenance Logs And Records (YMF)
89M	Naval Aviation Quality Assurance Administrative (YMG)
892	AERO 1-A Airborne Missile Control System IMA (FRB)
894	F-4J Weapons System Specialist OMA (FRB)
895	F-4 AWG-10 Missile Control System Familiarization (FEC)
897	Air Launched Weapons Guided Missile IMA (WMI)
90C	J-79-GE-8/10 Three Degree IMA (EJD)
90Z	F-4B/J Power Plant And Related System OMA (J-79-GE-8/10) (FAE)

Code	Description
907	F-4 Aircraft Servicing & Line Operations OMA (Plane Captain) (FBG)
908	F/RF-4B/J Aircraft Mechanics OMA (FLQ)
91A	NC-8A Mobile Electric Power Plant IMA (YDB)
91C	Aviation Support Equipment NC-10B Mobile Electric Power Plant Systems IMA (YDK)
91D	Aviation Support Equipment Hydraulic Test Stand AHT-63/64 IMA (YEA)
91K	Hydraulic Sytems OMA (HAG)
910	F/RF-4B/J J79-GE-8/10 Power Plant IMA With Hot Section Repair (FLP)
912	MC-2 Compass Calibrator OMA (BMA)
914	AN/ASW-15 AN/ASW-16 Automatic Flight Control System IMA (BPB)
916	Aviation Support Equipment GTC-85 IMA (YCA)
917	Aviation Support Equipment GTCP-100 & Enclosures IMA (YCB)
92L	F-4B/J/N Aircraft Egress & Environmental Control Systems OMA (FAG)
92M	F-4B/J Airframe & Hydraulic Systems OMA (FAB)
92N	F-4B Electrical System OMA (FAJ)
92P	F/RF-4B/J Air Data Computer Set IMA (FAL)

Code	Description
92T	F-4 Data Link System IMA (FBZ)
92U	AN/AWG-10 Transmitter & Antenna Positioning IMA (FEK)
92W	F-4B/J Power Generating System IMA (FEP)
92X	F-4 Basic Electrical Systems OMA (FEG)
92Y	F-4B/J Advanced Electrical OMA (FEH)
93J	F-4B/J RF-4B Airframes Maintenance (FLR)
93L	MK-4 Gun Pod Maintenance (WGB)
93W	F-4B/J Armament Missile And Weapon Control System OMA (FAP)
932	RF-4B Electrical Systems OMA FKM)
933	RF-4B Electrical Systems OMA (FLS)
94M	F-4J AN/AWG-10A Missile Control System Transitional IMA
94N	AN/AWG-10 Missile Control System Transitional IMA
94S	F-4J AN/AWG-10A Missile Control System OMA
94T	F-4J AN/AWG-10A Missile Control System OMA(Basic)
94V	AN/AWG-10A Missile Control System IMA
94W	AN/AWG-10A Missile Control System IMA (Basic)
95J	Aviation Machinists Mate AD Entry Level
95L	Aviation Machinists Mate AD (A) Entry Level
95T	Aviation Support Equipment NR-5C Mobile Air Conditioner IMA YEC
95W	Ground Support Equipment Charging and Starting

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